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Article

Supplementary description of *Liacarus neonominatus* Subías, 2004, with remarks on the genus *Liacarus* (Acari, Oribatida, Liacaridae)

Sergey G. Ermilov[1*], Jenő Kontschán[2, 3], Andrey V. Soromotin[4], Nikita A. Shulaev[5] and Badamdorj Bayartogtokh[6]

1. University of Tyumen, Institute of Environmental and Agricultural Biology (X-BIO), Tyumen, Russia; E-mail: ermilov acari@yandex.ru
2. Plant Protection Institute, HUN-REN Centre for Agricultural Research, Budapest, Hungary; E-mail: kontschan.jeno@atk.hun-ren.hu
3. Széchenyi István University, Department of Plant Sciences, Albert Kázmér Faculty of Mosonmagyaróvár, Mosonmagyaróvár, Hungary
4. University of Tyumen, Research Institute of Ecology and Natural Resource Management, Russia; E-mail: asoromotin@mail.ru
5. University of Tyumen, Laboratory of Memristor Materials, Center for Nature-Inspired Engineering, School of Natural Sciences, Russia; E-mail: n.a.shulaev@utmn.ru
6. National University of Mongolia, Department of Biology, School of Arts and Sciences, Ulaanbaatar, Mongolia; E-mail: bayartogtokh@num.edu.mn

[*] Corresponding author

ABSTRACT
The supplementary description of *Liacarus neonominatus* Subías, 2004 (Oribatida, Liacaridae) is presented, based on the material collected from soil and sand in a shrub-lichen tundra, Yamal Peninsula, Western Siberia, Russia. The main morphological traits of this species are summarized. The taxonomic status of some liacarid genera related with *Liacarus* is discussed, resulting in the following taxonomic proposals: *Liacarus* Michael, 1898 (= *Dorycranosus* Woolley, 1969 **syn. nov.**, = *Procorynetes* Woolley, 1969 **syn. nov.**, = *Rhaphidosus* Woolley, 1969 **syn. nov.**).

KEY WORDS: liacarid mites, morphology, Russia, taxonomy, Western Siberia.

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INTRODUCTION

The oribatid mite species *Dorycranosus arcticus* (Oribatida, Liacaridae) was originally described by Grishina (1984) from Yamal Peninsula, Western Siberia, Russia. Subías (2004) moved this species to the genus *Liacarus* Michael, 1898, where its species name was preoccupied by Banks (1899), therefore, he proposed the new name, *Liacarus neonominatus* Subías, 2004 (within subgenus *Dorycranosus*).

Currently, the distribution area of *L. neonominatus* covers from Western Siberia to the Far East of Russia. It inhabits different substrates (e.g. soil-litter, moss, lichen) mainly in typical and mountain

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tundra, and coniferous forests (Grishina 1984, 1985; Ryabinin and Pankov 2002; Ryabinin 2015).

The original description of *L. neonominatus* was correct and species is well discernible, but it was incomplete. In particular, the description lacks length of the body setae and the certain details concerning the gnathosoma, the podosomal region, and the posterior notogastral area; also, the leg setation and solenidia and the detailed leg figures were lacking. The main goals of our paper are: to present the supplementary description of this species, on the basis of the Western Siberian material, to summarize the main morphological traits, which will help with the identification of *L. neonominatus* in the future and to discuss the taxonomic status of the genera *Dorycranosus* Woolley, 1969, *Procorynetes* Woolley, 1969 and *Rhaphidosus* Woolley, 1969, which are morphologically similar to *Liacarus*.

MATERIALS AND METHODS

Sampling

Samples of soil and sand were taken from shrub-lichen tundra using a small shovel. Mites were extracted from the samples in Tyumen using modified Berlese funnels by drying the samples for seven days until their completely dry condition without additional heating or lighting. Micro-arthropods were fixed with 75% alcohol.

Observation and documentation

For measurement and illustration, specimens were mounted in lactic acid on temporary cavity slides. All measurements are in micrometers (μm); body length was measured in lateral view, from the tip of the rostrum to the posterior edge of the notogaster; notogastral width refers to the maximum width in dorsal aspect; setal lengths were measured in lateral aspect. Formulas for leg setation are given in parentheses according to the sequence trochanter-femur-genu-tibia-tarsus (famulus included); formulas for leg solenidia are given in square brackets, according to the sequence genu-tibia-tarsus. Drawings were made with a camera lucida using a Leica DM 2500 transmission light microscope; for SEM images alcohol preserved mites were dusted with gold and scanned with the aid of a TESCAN Mira3 LMU SEM microscope.

Terminology

Morphological terminology used in this paper mostly follows that of papers on Liacaridae (e.g., Ermilov and Kalúz 2013; Ermilov 2020); also, Norton (1977) for leg setal nomenclature and Norton and Behan-Pelletier (2009) for overview.

Abbreviations

Prodorsum: *mpr* = median part of rostrum; *ltr* = lateral tooth of rostrum; *lam* = lamella; *ltl* = lateral tooth of lamella; *mtl* = medial tooth of lamella; *ro*, *le*, *in*, *bs* = rostral, lamellar, interlamellar, and bothridial setae, respectively; *bo* = bothridium; *tu* = tutorium; *D* = dorsophragma; *P* = pleurophragma. **Notogaster:** *c*, *la*, *lm*, *lp*, *h*, *p* = setae; *ia*, *im*, *ip*, *ih*, *ips* = lyrifissures; *gla* = opisthonotal gland opening. **Gnathosoma:** *a*, *m*, *h* = subcapitular setae; *or* = adoral seta; *d*, *l*, *sup*, *inf*, *cm*, *ul*, *su*, *vt*, *lt* = palp setae; ω = palp solenidion; *cha*, *chb* = cheliceral setae; *Tg* = Trägårdh's organ. **Epimeral and lateral podosomal regions:** *1a–1c*, *2a*, *3a–3c*, *4a–4c* = epimeral setae; *PdI* = pedotectum I; *dis* = discidium; *cir* = circumpedal carina. **Anogenital region:** *g*, *ag*, *an*, *ad* = genital, aggenital, anal, and adanal setae, respectively; *iad* = adanal lyrifissure; *po* = preanal organ. **Legs:** *Tr*, *Fe*, *Ge*, *Ti*, *Ta* = leg trochanter, femur, genu, tibia, tarsus, respectively; ω, φ, σ = solenidia; ε = famulus; *d*, *l*, *v*, *bv*, *ev*, *ft*, *tc*, *it*, *p*, *u*, *a*, *s*, *pv*, *pl* = setae; *pa* = porose area.

TAXONOMY

Family Liacaridae
Liacarus Michael, 1898
Subgenus *Liacarus* (*Liacarus*) Michael, 1898

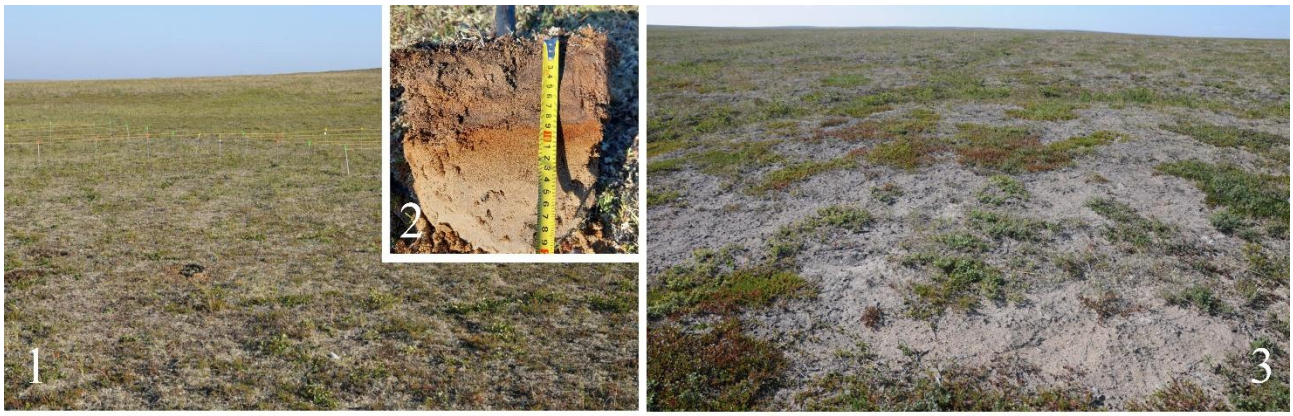
Type species: *Oribata nitens* Gervais, 1844

***Liacarus* (*Liacarus*) *neonominatus* Subías, 2004**
(syn.: *Dorycranosus arcticus* Grishina, 1984, preoccupied by Banks (1899))

Material

Two specimens (two males): Russia, Western Siberia, Yamal Peninsula, near Lake Yaroto-1, shrub-lichen tundra, 67°51'34.61" N, 71°5'27.45" E, practically undisturbed moist soil (locality 2, Figs. 1, 2), 10.viii.2024 (A.V. Soromotin); six specimens (five males and one female): the same, but dry loamy sand (locality 3, Fig. 3).

All specimens (preserved in 70% solution of ethanol with a drop of glycerol) are deposited in the collection of the University of Tyumen, Museum of Zoology, Tyumen, Russia.



Figures 1–3. Photos of localities and habitat of *Liacarus neonominatus* Subías, 2004 – 1. Locality 2; 2. Upper part of the soil profile in locality 2; 3. Locality 3.

Supplementary description (Figs. 4–28)

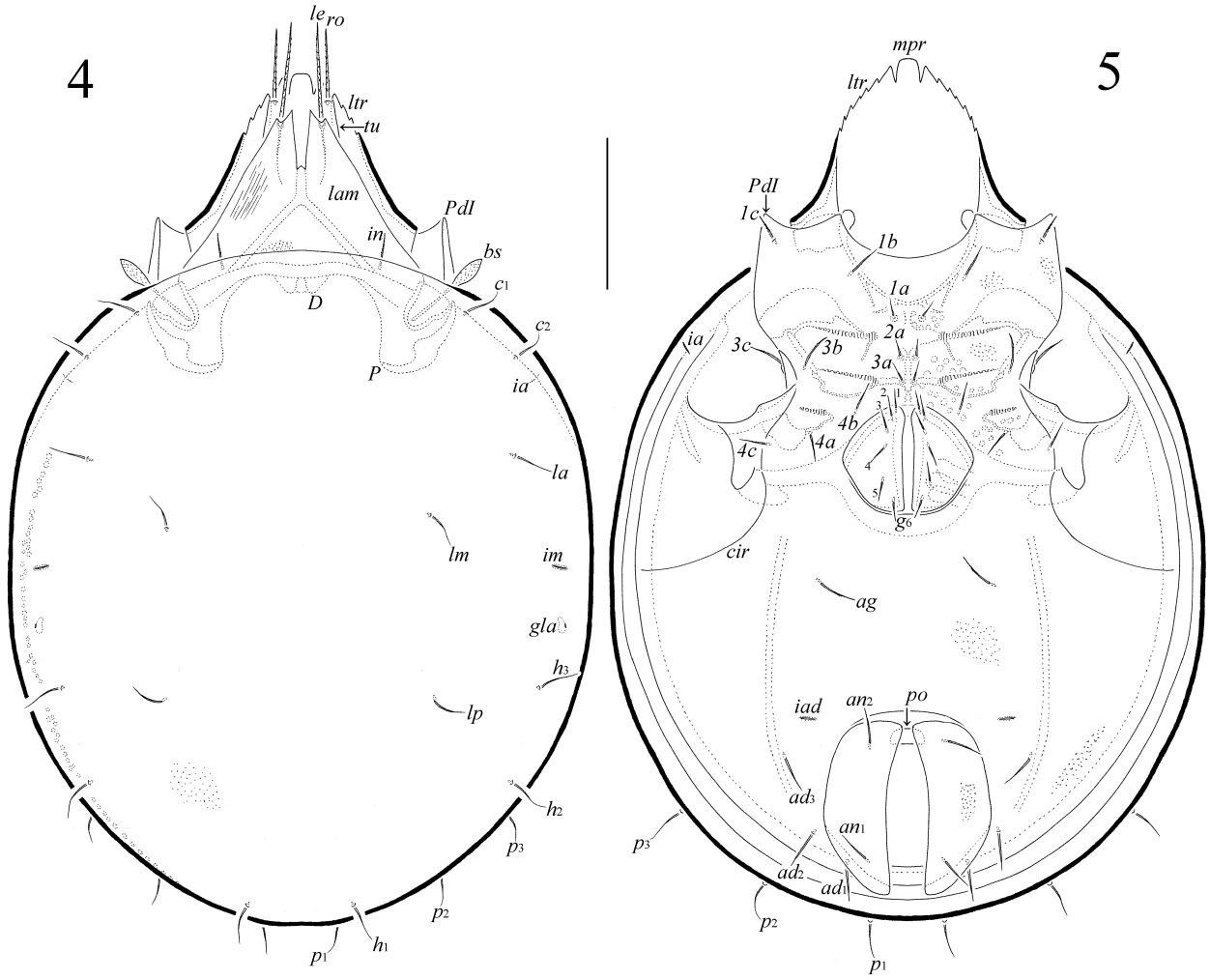
Measurements – Body length: 555–585 (seven males), 630 (one female); notogaster width: 390–420 (seven males), 480 (one female).

Integument (Figs. 4, 5, 20, 23, 24, 26) – Body brown. Surface densely microsculpturing tuberculate (visible under high magnification in dissected specimens); lamella and dorsal part of tutorium longitudinally striate; lateral side of body partially with microgranulate cerotegument.

Prodorsum (Figs. 4–6, 8, 9, 17–24) – Rostrum with median rectangular ledge bordered by two deep incisions and with several (six to eight) lateral teeth (anterior tooth is largest). Lamella (excluding cusp) shorter than half of prodorsum; lamellar cusp slightly shorter than basal part of lamella, distally with strong inner tooth and small lateral outer tooth (sometimes reduced); cusps clearly separated medially, parallel or slightly divergent, connected mediobasally by one small interlamellar tooth. Rostral (52–56) and lamellar (71–75) setae rod-like, barbed; lamellar seta inserted in distal part of lamellar cusp; interlamellar seta (26–28) distinctly thinner than rostral and lamellar setae, setiform, slightly barbed; bothridial seta (34–41) with short exposed stalk and longer, fusiform (narrowed or pointed distally), slightly barbed head; in some specimens, bothridial head has apical spike; exobothridial seta not observable. Tutorium long, ridge-like, directed to rostrum, continue

lateral and near the insertion of rostral seta.

Notogaster (Figs. 4, 6, 7, 17–21, 25) – Eleven pairs of notogastral setae (28–34) setiform, smooth; each seta inserted on small tubercle. Opisthonotal gland opening and all lyrifissures well observable.

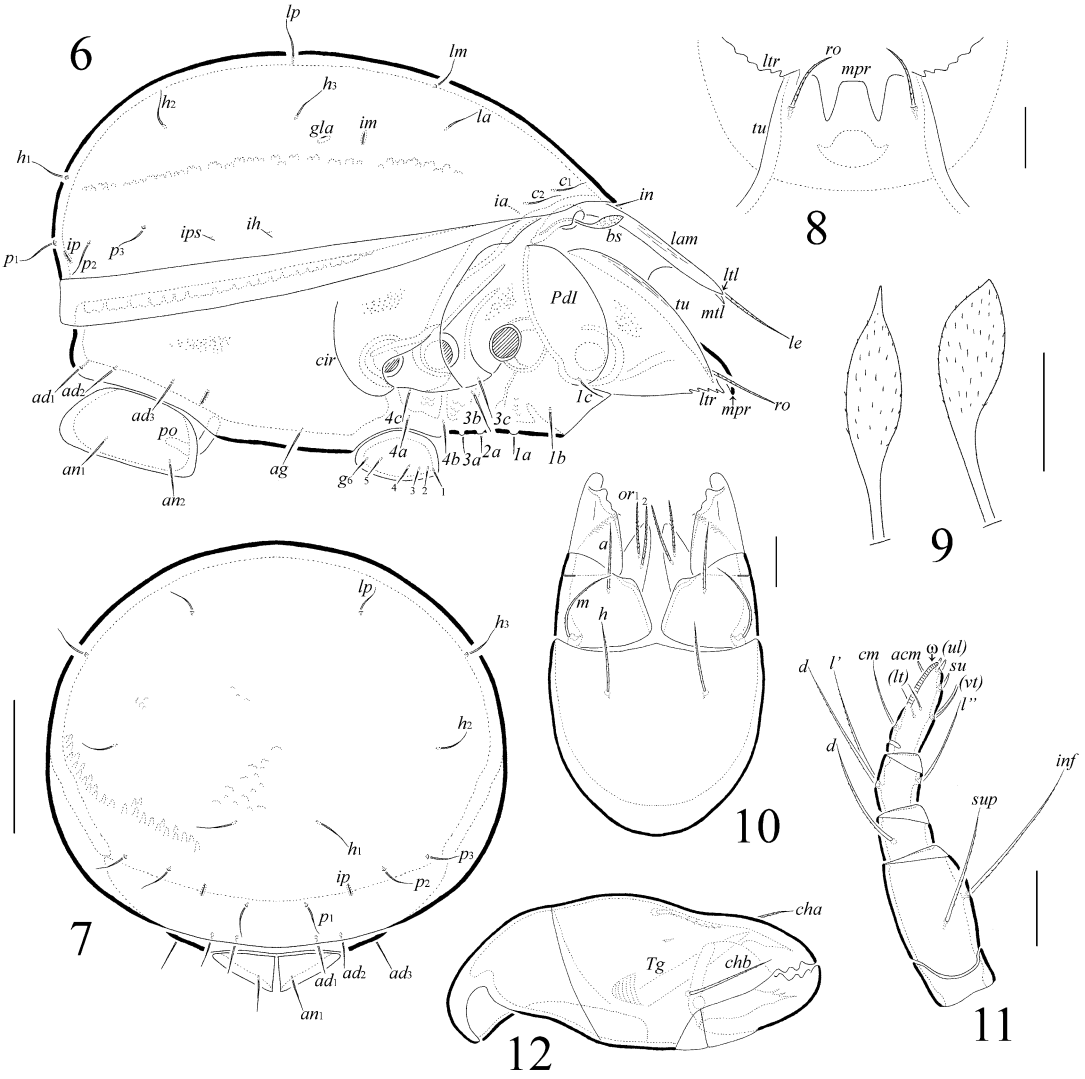


Figures 4–5. *Liacarus neonominatus* Subías, 2004 (adult, gnathosoma and legs not shown) – 4. Dorsal view; 5. Ventral view.

Gnathosoma (Figs. 10–12) – Subcapitulum size: 154–169 × 86–90; subcapitular setae (*a*, *h*: 30–34; *m*: 37–41) setiform, slightly barbed; both adoral setae (26–30) setiform, barbed. Palp length: 90–97; setation: 0-2-1-3-9(+ω); postpalpal seta (7–9) spiniform, smooth. Chelicera length: 154–169; cheliceral setae (*cha*: 52–56; *chb*: 37–41) setiform, barbed.

Epimeral and lateral podosomal regions (Figs. 5, 6, 19) – Epimeral setal formula: 3-1-3-3; setae *1a*, *2a*, *3a* (17–19) setiform, smooth, others (*1b*, *3b*, *3c*: 30–34; *1c*, *4a*, *4b*, *4c*: 26–28) setiform, slightly barbed; *1a*, *2a*, *3a*, *3c* inserted on distinct tubercles, others on slight tubercles. Circumpedal carina distinct.

Anogenital region (Figs 5–7, 19, 26) – Anogenital setal formula: 6-1-2-3; genital (17–19), anal (30–34) and adanal (30–34) setae setiform, erect, smooth; all adanal setae inserted on slight tubercles; both aggenital setae (30–34) setiform, erect, slightly barbed. Adanal lyrifissure transverse.



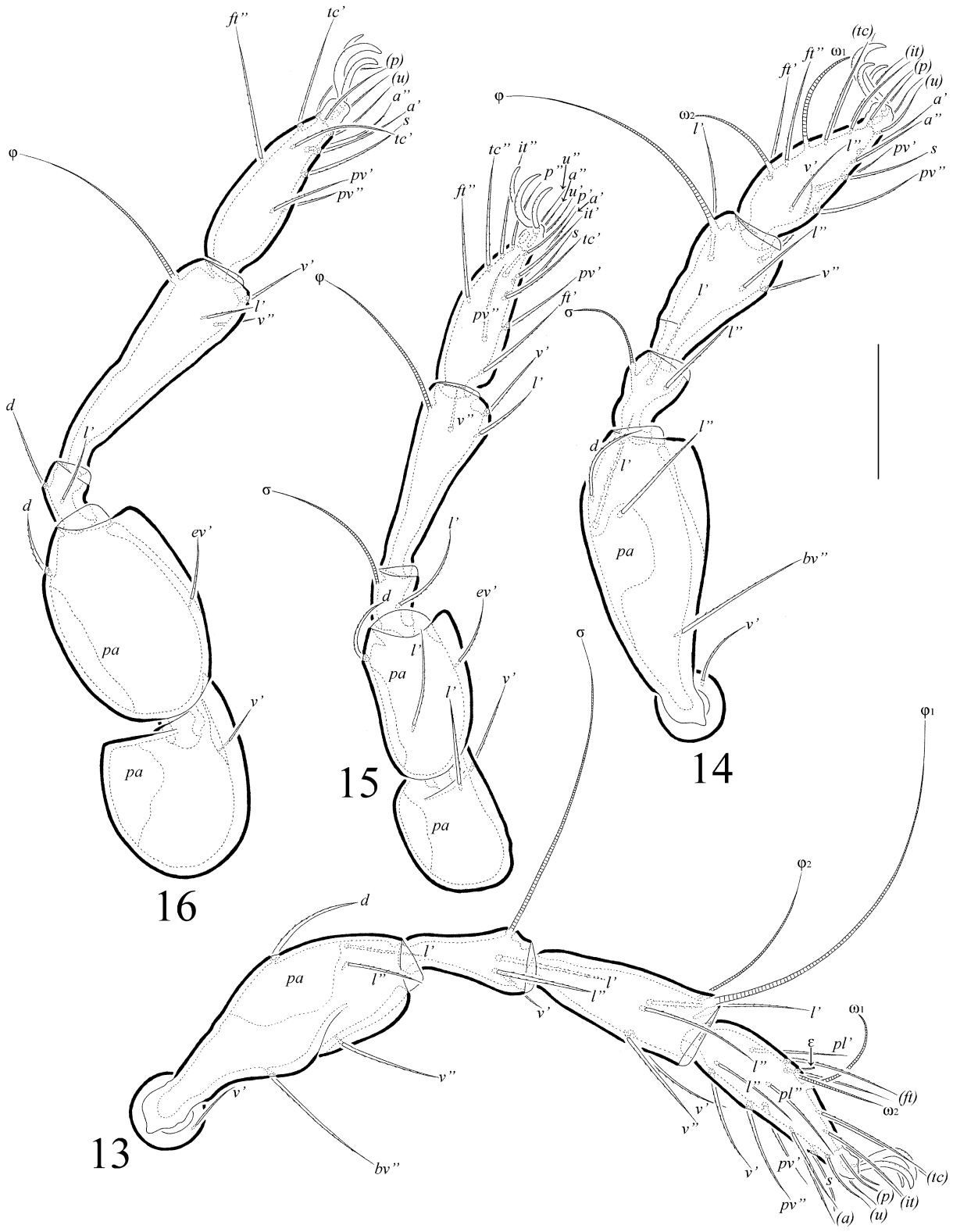
Figures 6–12. *Liacarus neonominatus* Subías, 2004 (adult) – 6. Right lateral view (gnathosoma and legs not shown); 7. Posterior view; 8. Rostrum, anterior view; 9. Variability of bothridial seta, lateral view; 10. Subcapitulum, ventral view; 11. Palp, right, antiaxial view; 12. Chelicera, right, antiaxial view.

Legs (Figs. 13–16, 19, 21, 27, 28) – Median claw thicker than lateral ones, all slightly barbed on dorsal side. Dorsoparaxial porose area on all femora and on trochanters III, IV distinct. Formulas of leg setation and solenidia: I (1-5-3-4-20) [1-2-2], II (1-4-2-4-16) [1-1-2], III (2-3-1-3-15) [1-1-0], IV (1-2-2-3-12) [0-1-0]; homology of setae and solenidia indicated in Table 1; seta *s* on tarsus I eupathidial, located between paired setae *u* and *a*; solenidia ω_1 and ω_2 on tarsi I, II and σ on genu III rod-like, rounded apically, other solenidia setiform to subflagellate.

Table 1. Leg setation and solenidia of adult *Liacarus neonominatus* Subías, 2004.

Leg	*Tr*	*Fe*	*Ge*	*Ti*	*Ta*
I	*v'*	*d, (l), bv'', v''*	*(l), v',* σ	*(l), (v),* φ_1, φ_2	*(ft), (tc), (it), (p), (u), (a), s, (pv), v', (pl), l'',* ε, ω_1, ω_2
II	*v'*	*d, (l), bv''*	*(l),* σ	*(l), (v),* φ	*(ft), (tc), (it), (p), (u), (a), s, (pv), l'',* ω_1, ω_2
III	*l', v'*	*d, l', ev'*	*l',* σ	*l', (v),* φ	*(ft), (tc), (it), (p), (u), (a), s, (pv)*
IV	*v'*	*d, ev'*	*d, l'*	*l', (v),* φ	*ft'', (tc), (p), (u), (a), s, (pv)*

Note: Roman letters refer to normal setae; Greek letters to solenidia (except ε = famulus); single quotation mark (') designates setae on the anterior and double quotation mark (") setae on the posterior side of a given leg segment; parentheses refer to a pair of setae.

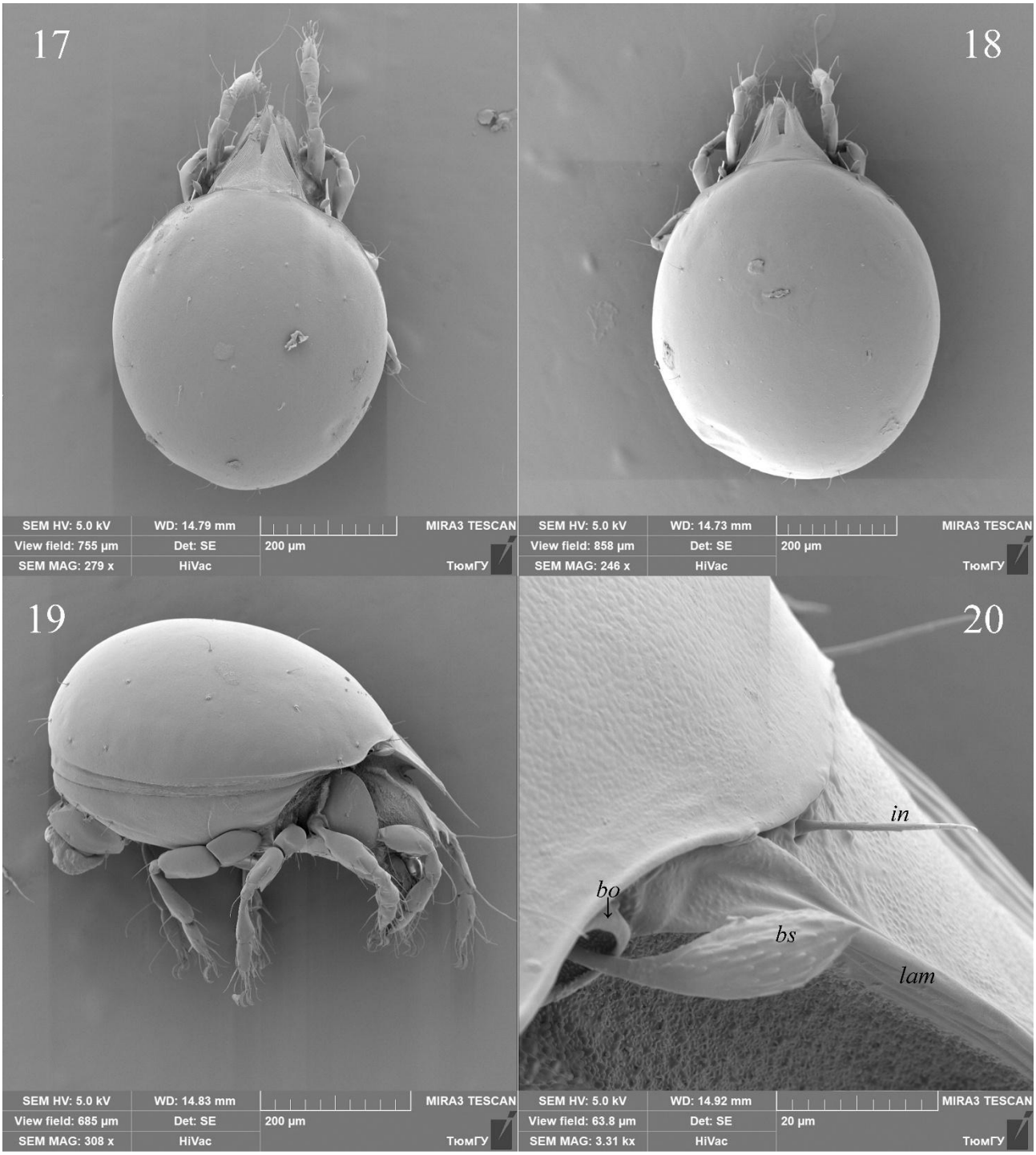


Figures 13–16. *Liacarus neonominatus* Subías, 2004 (adult) – 13. Leg I, right, antiaxial view; 14. Leg II, right, antiaxial view; 15. Leg III, left, antiaxial view; 16. Leg IV, left, antiaxial view.

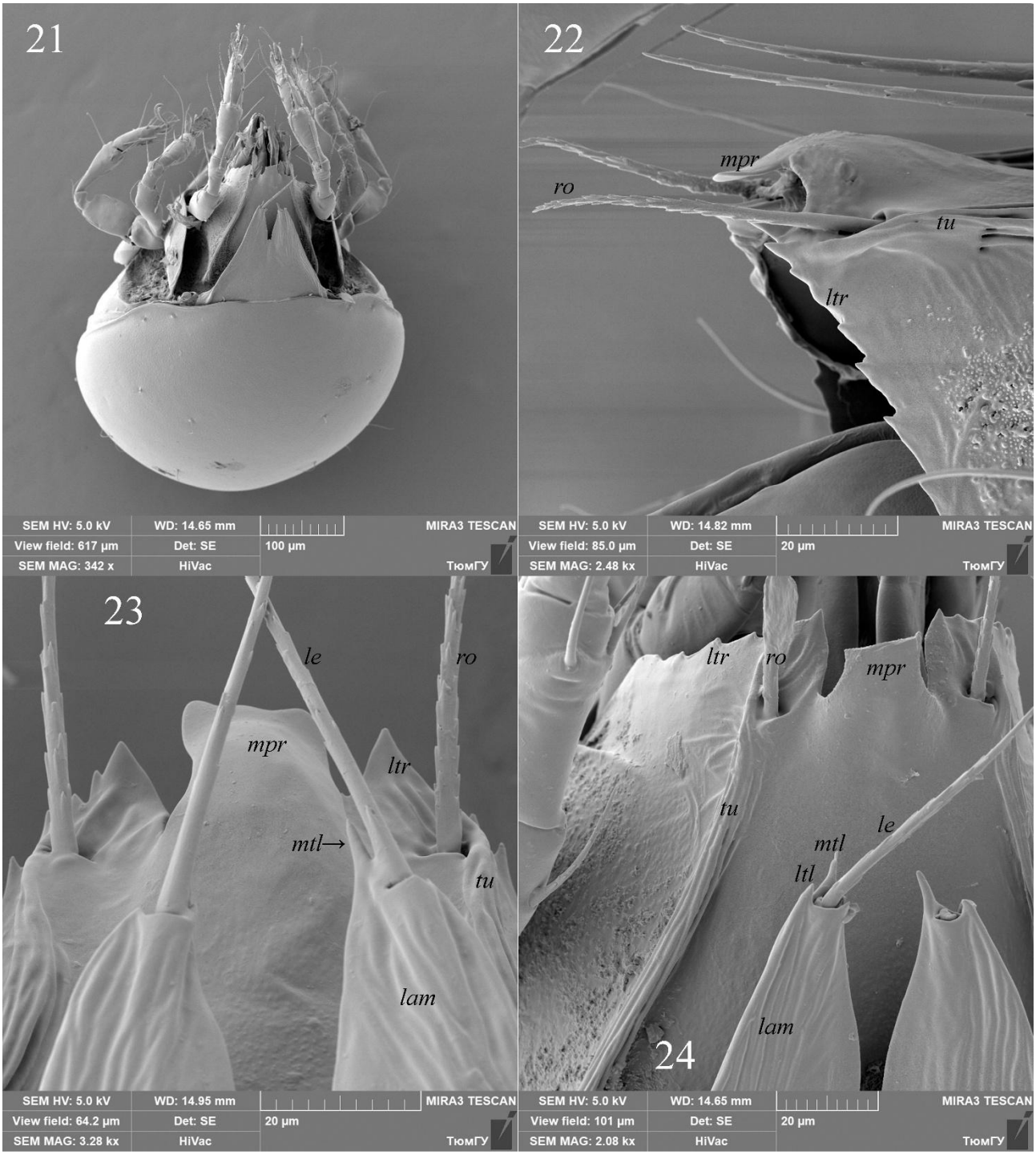
Diagnosis

Based on our supplementary description and on the original description (Grishina 1984) of adult *L. neonominatus*, we propose the following diagnostic morphological traits for this species:

Body length: 522–665. Surface microsculpturing tuberculate; lamella striate. Rostrum with median rectangular ledge, two incisions and several lateral teeth. Lamellar cusp distally with strong inner tooth and small outer tooth (sometimes reduced); cusps separate medially, connected mediobasally by small tooth. Rostral and lamellar setae medium-sized, rod-like, barbed; interlamellar seta short, setiform, slightly barbed; bothridial seta short, fusiform (sometimes with apical spike), slightly barbed, with head longer than stalk. All notogastral setae short, setiform, smooth, inserted on tubercles. All epimeral and anogenital setae short, setiform. Adanal lyrifissure transverse.



Figures 17–20. *Liacarus neonominatus* Subías, 2004 (adult, SEM micrographs) – 17, 18. Dorsal view; 19. Right lateral view; 20. Interlamellar and bothridial setae.

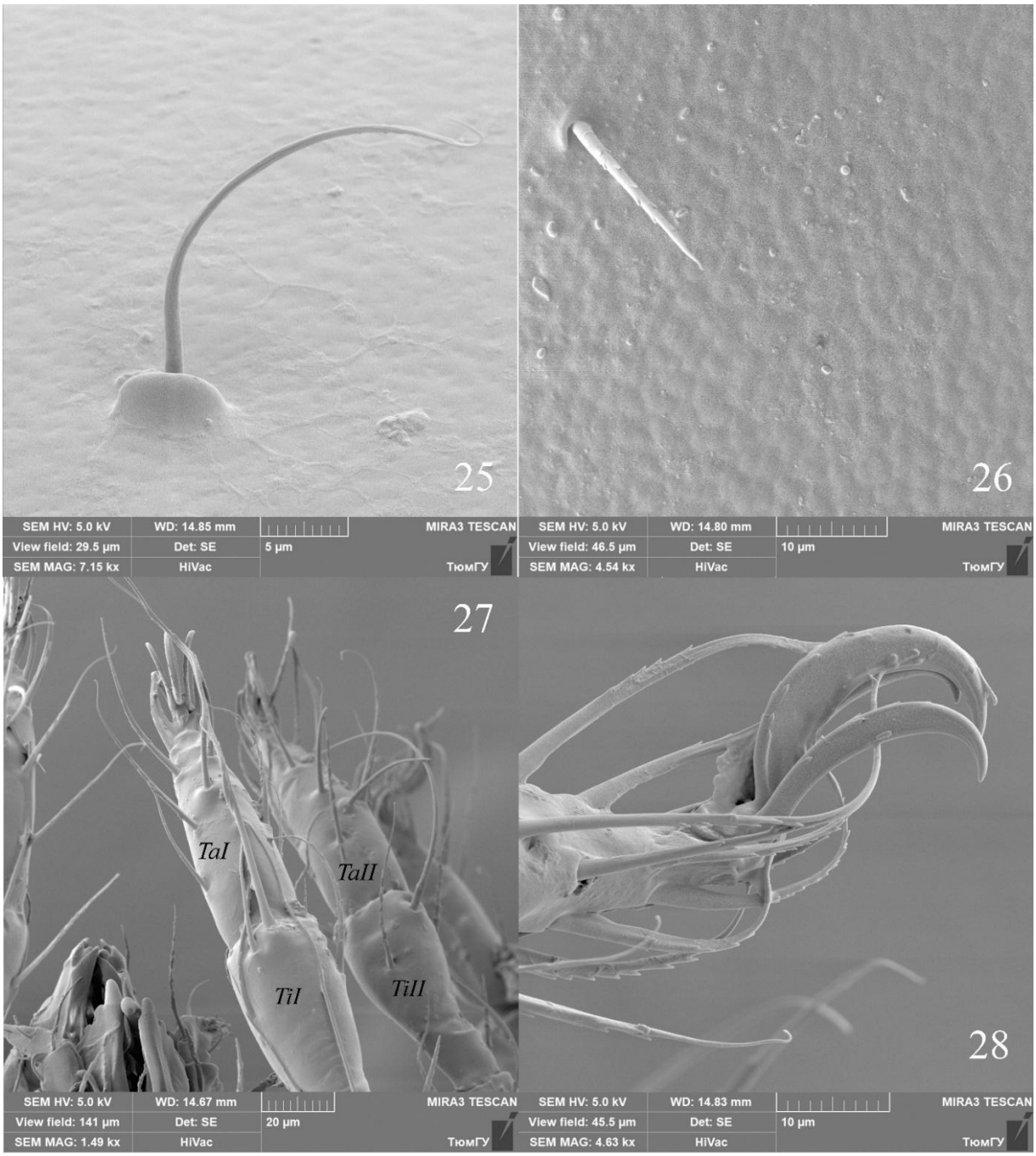


Figures 21–24. *Liacarus neonominatus* Subías, 2004 (adult, SEM micrographs) – 21. Anterior view; 22. Rostrum, lateral view; 23, 24. Anterior part of prodorsum, anterior view.

GENERAL REMARKS

1. Family Xenillidae. It was established by Woolley and Higgins (1966). Many authors (e.g., Balogh 1985; Weigmann 2006; Norton and Behan-Pelletier 2009) rejected the family status for Xenillidae, consider Xenillidae to be a junior synonym of Liacaridae, since the main difference

between these families (surface sculpturing) is not diagnostic at the family level, and we agree with these authors. However, some authors (e.g., Grobler *et al*. 2003; Subías 2004, 2022; Liu and Chen 2024) supported Xenillidae as a valid taxon.



Figures 25–28. *Liacarus neonominatus* Subías, 2004 (adult, SEM micrographs) – 25. Notogastral seta *lp*, lateral view; 26. Aggenital seta, lateral view, and aggenital sculpturing; 27. Anterior part of legs I, II, dorsal view; 28. Anterior part of leg tarsus III, lateral view.

2. Genera *Liacarus*, *Dorycranosus*, *Procorynetes*, *Rhaphidosus*. The genus *Liacarus* Michael, 1898 was described by Michael (1898), with *Oribata nitens* Gervais, 1844 as type species. Woolley (1969) established three new genera within Liacaridae, namely: *Dorycranosus* Woolley, 1969, with *Liacarus abdominalis* Banks, 1906 as type species; *Procorynetes* Woolley, 1969, with *Liacarus*

nigerrimus Berlese, 1916 as type species; and *Rhaphidosus* Woolley, 1969, with *Liacarus carolinensis* Banks, 1906 as type species. These genera are similar to each other, differing mainly by the morphology of their bothridial setae: spindle-shaped, with setiform or bacillar apex in *Liacarus*; clavate/fusiform in *Dorycranosus*; capitate in *Procorynetes*; and setiform/bacilliform in *Rhaphidosus*. Fujikawa and Aoki (1970) described species with spindle-shaped, fusiform or clavate bothridial setae within the genus *Liacarus*, and moreover Aoki (1980) combined all the Japanese species with various types of bothridial setae in this genus, which formerly assigned either to *Dorycranosus* or *Procorynetes*. At present, some authors supported their generic status (e.g., Pfingstl & Schatz 2021; Schatz 2022; Behan-Pelletier & Lindo 2023), but the others downgraded *Dorycranosus*, *Procorynetes*, and *Rhaphidosus* to the subgeneric level under *Liacarus* (Salazar-Fillippo and Miko 2022; Subías 2022; Liu and Chen 2024).

The importance of the morphology of the bothridial setae in the taxonomic differentiation at the supraspecies level is varies in Oribatida: in some superfamilies it can be widely used (e.g. Oppioidea), while in others it is practically not taken into account (e.g. Galumnoidea). In case of Liacaridae, the use of bothridial setal morphology as a taxonomic feature to distinguish different genera is controversial. On the one side, as noted above, some genera/subgenera related with *Liacarus* (*Dorycranosus*, *Procorynetes*, *Rhaphidosus*) are supported based on the morphology of their bothridial setae. On the other side, another related (with *Liacarus*) genus *Xenillus* Robineau-Desvoidy, 1839 comprises species with all morphological types of the bothridial setae (clavate/fusiform; spindle-shaped, with setiform or bacillar apex; capitate; setiform/bacilliform). Hence, it is obviously illogical to distinguish some genera/subgenera of Liacaridae based on bothridial setal morphology while others not.

It is worth to note that *Liacarus* and *Xenillus* are clearly separate genera, differing from each other by the body surface (without heavy sculpturing in *Liacarus* versus with heavy sculpturing in *Xenillus*), therefore, the inclusion of species with different types of bothridial setae in both genera is may be correct, which indicates the morphology of the bothridial seta as a species (not generic/subgeneric) character. Therefore, the allocation for *Dorycranosus*, *Procorynetes*, *Rhaphidosus* from *Liacarus* is unnecessary.

Based on above listed explanations, we propose the following taxonomic actions: *Liacarus* Michael, 1898 (= *Dorycranosus* Woolley, 1969 **syn. nov.**, = *Procorynetes* Woolley, 1969 **syn. nov.**, = *Rhaphidosus* Woolley, 1969 **syn. nov.**). All representatives of *Dorycranosus*, *Procorynetes*, *Rhaphidosus* should be combined with *Liacarus*.

3. *Leuroxenillus*, *Stenoxenillus*. Woolley and Higgins (1966) established two other genera related with *Liacarus*, namely: *Leuroxenillus* Woolley & Higgins, 1966, with *Leuroxenillus trichionus* Woolley & Higgins, 1966 as type species, and *Stenoxenillus* Woolley & Higgins, 1966, with *Stenoxenillus atraktus* Woolley & Higgins, 1966 as type species (their third proposed new genus, *Stonyxenillus* Woolley & Higgins, 1966, is similar to *Xenillus*). These genera characterized mainly by the morphology of the lamellae: fused mediodistally by strong toothlike process, broad, dentate distally in *Leuroxenillus*; well separate, very narrow, with lateral tooth in *Stenoxenillus*. Later, Woolley (1970) questioned the validity of *Stenoxenillus* and considered the type species to be a representative of *Stonyxenillus*. Balogh and Balogh (1992) synonymized *Leuroxenillus* with *Liacarus*, but saved *Stenoxenillus*. Grobler *et al*. (2003) revised *Stenoxenillus* and supported its generic status. Subías (2004, 2022) considered both as junior synonyms of *Liacarus*. We preliminary agree with the latter synonymies, because the morphology of the lamellae (e.g., in *Liacarus* and *Xenillus*) is highly variable, however, we admit that the study of this morphological aspect within Liacaridae may be promising.

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توصیف تکمیلی در مورد *Liacarus neonominatus* Subías, 2004، همراه با بحثی درباره جنس *Liacarus* (Acari, Oribatida, Liacaridae)

سرگی جی. ارمیلوف[1*]، جنو کونتشان[2،3]، آندری و. سوروموتین[4]، نیکیتا آ. شولایف[5] و بادامدورج بایارتوکتوخ[6]

۱. دانشگاه تیومن، مؤسسه زیست‌شناسی زیست‌محیطی و کشاورزی(X-BIO)، تیومن، روسیه؛ رایانامه: ermilovacari@yandex.ru

۲. مؤسسه گیاهپزشکی، مرکز تحقیقات کشاورزی HUN-REN، بوداپست، مجارستان؛ رایانامه: kontschan.jeno@atk.hun-ren.hu

۳. دانشگاه سچینی ایستوان، گروه علوم گیاهی، دانشکده آلبرت کازمر موسونماگیاروار، موسونماگیاروار، مجارستان

٤. دانشگاه تیومن، مؤسسه تحقیقات بوم‌شناسی و مدیریت منابع طبیعی، روسیه؛ رایانامه: asoromotin@mail.ru

۵. دانشگاه تیومن، آزمایشگاه مواد ممریستور، مرکز مهندسی الهام‌گرفته از طبیعت، دانشکده علوم طبیعی، روسیه؛ رایانامه: n.a.shulaev@utmn.ru

٦. دانشگاه ملی مغولستان، گروه زیست‌شناسی، دانشکدهٔ هنر و علوم، اولان‌باتار، مغولستان؛ رایانامه: bayartogtokh@num.edu.mn

* نویسنده مسئول

چکیده

توصیف تکمیلی *Liacarus neonominatus* Subías, 2004 (Oribatida, Liacaridae) بر اساس نمونه‌های جمع‌آوری‌شده از خاک و ماسه در توندرای بوته‌ای-گلسنگی در شبه‌جزیره یامال، سیبری غربی، روسیه ارایه شده است. ویژگی‌های اصلی ریخت‌شناسی این گونه خلاصه شده‌اند. وضعیت رده‌بندی برخی از جنس‌های این خانواده همراه با *Liacarus* مورد بحث قرار گرفته است که منجر به پیشنهادهای آرایه‌شناختی زیر شده است: *Liacarus* Michael, 1898 (= *Dorycranosus* Woolley, 1969 **syn. nov.**, = *Procorynetes* Woolley, 1969 **syn. nov.**, = *Rhaphidosus* Woolley, 1969 **syn. nov.**).

واژگان کلیدی: هرناهای لیاکارید، ریخت‌شناسی، روسیه، آرایه‌شناسی، سیبری غربی.

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